USE OF FISH PRODUCTS IN BLUEBACK SALMON DIETS

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Explanatory Note

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United States Department of the Interior, Douglas McKay, Secretary
Fish and Wildlife Service, John L. Farley, Director

USE OF FISH PRODUCTS IN BLUEBACK SALMON DIETS

EVALUATION AND UTILIZATION OF CANNERY WASTES AND OTHER MATERIALS IN HATCHERIES

Report of experimental work carried out from 1947 to 1951 by the Seattle Fishery Technological Laboratory, Branch of Commercial Fisheries in collaboration with the Leavenworth Laboratory Western Fish Cultural Investigations, Branch of Fishery Biology, and the Fishery Products Laboratory, Ketchikan, Alaska.

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Chemical and technological studies under the general supervision of Maurice E. Stansby, Chief, Pacific Coast and Alaska Technological Research.

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Hatchery feeding studies under the general supervision of Roger E. Burrows, Aquatic Biologist.

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PARTICIPATING AGENCIES

This project was financed to a large extent from Federal funds transferred from the Maintenance and Improvement of Existing River and Harbor Works Appropriation for use in the Lower Columbia River hatchery feed program. Agencies participating in or cooperating with this program included:

1. Alaska Fisheries Experimental Commission, Ketchikan, Alaska

2. Fish and Wildlife Service
   a. Branch of Commercial Fisheries
      (1) Fishery Technological Laboratory, Seattle, Washington
      (2) Fishery Products Laboratory, Ketchikan, Alaska
   b. Branch of Fishery Biology
      (1) Western Fish Cultural Investigations, Leavenworth, Washington
3. Oregon Fish Commission, Sea Foods Laboratory, Astoria, Oregon

4. Washington State Fisheries Department, Seattle, Washington

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ABSTRACT

Microbiological methods of assay for niacin, riboflavin, biotin, and vitamin B_{12} were adapted to hatchery feed materials. Data on composition of 49 hatchery feed components and 42 mixed hatchery-fish diets are presented for the foregoing vitamins and for moisture, protein, oil, and ash. It was found that the component parts of salmon viscera vary widely in nutritive value for hatchery-fish feeding, and also the salmon eggs have by far the greatest nutritive value of any of these components. Other fish materials, such as halibut sawdust (the band-saw waste resulting from preparation of steaks from frozen halibut), whole rockfish, tuna viscera, tuna livers, and specially prepared fish meals, were evaluated as possible hatchery feed ingredients.

Practical commercial methods of collecting, sorting, and packing of salmon cannery waste were developed that allow shipment of the material from Alaska to fish hatcheries in the States at economically feasible costs. A special container, consisting of a burlap sack with inner polyethylene bag liner, was developed for use with salmon viscera.

Progress was made toward development of a cheap chemical preservative treatment for salmon eggs for use at salmon canneries which do not possess cold storage facilities. A large-scale collection of salmon viscera materials involving over 100,000 pounds of frozen products was made at Petersburg, Alaska. The material was shipped to Federal hatcheries

in the state of Washington for actual production use. Cost records showed that salmon viscera and eggs can be shipped from Alaska to Washington State at costs competitive with other local hatchery feeds presently used.

PART I. INTRODUCTION: REVIEW OF THE PROBLEM AND SCOPE OF THE STUDY

By G. Ivor Jones* and Maurice E. Stansby**

The Hatchery-Feed Problem

A complete program for the maintenance and rehabilitation of the fisheries of the Columbia River and its tributaries has been developed because of the depletion of the salmon runs in this great river system. Surveys (Barnaby 1945; Bryant 1949; and State of Washington 1949), have indicated numerous causes for the decline of the salmon runs and have recommended corrective programs for stream improvement and for increased hatchery propagation of salmon. At the present time an extensive state and federal collaborative program of hatchery construction in the lower Columbia River region is being undertaken. During the 10-year period of the plan, now under way, many existing hatcheries are being enlarged and about 24 new fish cultural stations will be constructed in Washington and Oregon. As the new hatcheries go into operation, the demand for nutritionally adequate feed for young salmon will increase accordingly. It has been estimated that the new stations will require as much as 3.5 million pounds of fish-feed per year. This expected new demand along with existing hatchery feed requirements will necessitate finding new feeds in adequate supply since present sources of supply of feeding materials are being utilized to near their maximum limit.

Scope of the Study

Early in 1947 the Seattle Fishery Technological Laboratory was enabled, by means of a grant from the Office of Technical Services, Department of Commerce, to carry out research investigations on the utilization of Alaskan salmon cannery waste. As a part of this project a cooperative study with the Leavenworth, Washington, salmon hatchery (figure I-1) was initiated to determine the value of salmon cannery waste as fish hatchery feed. Salmon viscera had previously been used in some hatcheries to replace a portion of the beef liver and other animal products used in the feeding of salmon fingerlings. Because the use of viscera in the diet had shown promise, it was believed worthwhile to attempt a critical evaluation of salmon waste in the diet of young salmon.

Figure I-1. Fish and Wildlife Service hatchery at Leavenworth, Washington where feeding tests were conducted.

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Salmon cannery waste amounts to about one-third the weight of the entire fish. In Alaska these waste portions are in most instances discarded by dumping at sea. The knowledge of a huge potential supply of the waste material in Alaska, estimated at more than 100,000,000 pounds annually, gave impetus to the effort to find suitable means of using this cannery waste. A discussion of this problem is presented in a report (Jones and Carrigan 1947) entitled, "Utilization of Salmon Cannery Waste--Literature Survey", Office of Technical Services Report, Part One, Section One, Department of Commerce, Cac-47-17, December 1947.

The present study deals with the critical evaluation of presently used feeding materials and exploration for new feeds. This work was carried out collaboratively during 1947 to 1951 inclusive by the Seattle Fishery Technological Laboratory and the Leavenworth Salmon Hatchery of the United States Fish and Wildlife Service.

Carefully controlled studies on the value of raw cannery waste and other feed materials at the Leavenworth Hatchery were carried out. This project also included studies on meal preparation from the raw products and other methods of processing and preserving the raw food material. Proximate composition as well as assays for certain vitamin constituents of the diet components was carried out at the Seattle Fishery Technological Laboratory.

The 1947 program

The collaborative investigations were inaugurated in 1947, late in the hatchery season; therefore, the initial experiments were necessarily limited in scope. However, it was possible to run a survival experiment with blueback salmon fingerlings (Oncorhynchus nerka) to determine the presence, if any, of anti-anemia factors in three different types of meal prepared from salmon viscera. Growth evaluation studies were also carried out on the same species with five different mixed diets composed of raw feeding materials and prepared meals, and also control feeding mixtures. The results of the first-year studies (Burrows, Robinson, and Palmer 1951) indicated that salmon viscera produced excellent growth when fed either as a single diet component or when fed in conjunction with meat products. It was observed that salmon viscera meals fed as 10 percent of the diet made a significant contribution to the growth rate. These meals included a low-temperature (100° F.) air-dried meal, an acetone-extracted meal (room temperature), and a flame-dried offal meal.

Fingerlings fed salmon viscera showed good growth and were in healthy condition at the end of the 12-week experimental period, but those fed salmon cannery waste minus the viscera were on the verge of acute anemia at the end of this period.

The 1948 program

After conclusion of the 1947 experiments a more extensive investigative program was carried out during 1948. A series of 12 different

meals were tested; some were prepared from Columbia River-Chinook salmon viscera and others from Alaskan pink salmon viscera and Alaskan pink salmon offal. In addition, a meal prepared from a purposely spoiled or decomposed pink salmon offal and a commercially manufactured flame-dried salmon offal meal were evaluated. The nutritive values of raw cannery wastes and diet mixtures containing these wastes, were compared with diet mixtures containing beef liver, hog liver, and hog spleen. Proximate composition was determined on 21 different diet components. A discussion and summary of these data was presented in a report (Karrick and Edwards 1948) entitled, "Utilization of Alaska Salmon Cannery Waste - Vitamin Content of Experimental Fish Hatchery Foods," Office of Technical Services Report, Part Two, Section Three, Department of Commerce, Cac-47-17, December, 1948.

It was found (Burrows, Robinson, and Palmer 1951) that the low-temperature tunnel-dried salmon viscera meal fed as 10 percent of the diet increased the growth rate of salmon fingerlings considerably above that produced by feeding flame-dried salmon offal meal. Temperature of meal preparation also proved to be important since the viscera meal dried at 100° F. stimulated greater growth than did a similar meal dried at a temperature of 145° F. It was also observed during these experimental feeding trials that dried fish meals added to the diet at water temperatures below 50° F. or before the fish had been feeding for 6 weeks increased the mortality rate and actually retarded growth. After 6 weeks on test and at water temperatures above 50° F. the addition of viscera meals to the diet produced significantly greater growth in the fingerlings than was produced by feeding the regular control diets.

The 1949 program

Results of the 1947 and 1948 feeding trials indicated that salmon viscera can be used to replace part of the meat gland products usually incorporated in the diet, with a definite increase in growth rate as well as affecting a considerable saving in the cost of the food items. During 1949, experiments were set up to determine the contribution to increased growth made by each of the various segregated portions of salmon viscera which are composed of roe, milt, digestive tract, and liver. Evaluation studies were also made on yellowfin tuna liver and on Dungeness crab waste meal. Tuna livers had become available for hatchery feeding due to a reduced demand for the livers for vitamin A production. Crab meal had shown some promise as fish food in nutritional studies carried out by McClaren, Herman, and Elvehjem (1947). Simultaneously, a chemical and vitamin study of raw livers, and liver meals of beef, yellowfin tuna, and albacore tuna prepared by steam-heated vacuum drying, lyophilizing, (freeze-drying), and acetone extraction was carried out by Jones and Hoyer (1950) at the Fishery Technological Laboratory in Seattle. It was hoped that information concerning liver meals might lead to their subsequent use as a replacement for part or all of the raw beef liver customarily included in the salmon diets.

It was found (Robinson, Palmer, and Burrows 1951) that salmon roe plus 10 percent viscera meal added as a binder, fed as total diet to young blueback salmon for a 24-week period induced greater growth than any combination of meat glands, viscera, and meal that had yet been tried. This increased growth was significant in contrast to the much poorer rate of growth obtained with the other fractions of salmon viscera. The lower growth rate of the fish fed viscera fractions other than roe was accompanied by an increased rate of mortality. This indicates that salmon roe contained the greatest growth potential for blueback salmon fingerlings of any food material yet tested. However, it was noted that during the first 12 weeks of the 24-week feeding period, the mortality rate of the fingerlings fed the salmon roe was somewhat higher than that observed for fingerlings fed the beef liver or mixed-meat-gland diets. This fact was considered in planning the 1950 feeding trials.

Fingerlings fed tuna livers with 10 percent viscera meal added as a binding agent, did not develop anemia; however, the diet did not support normal growth. The 1950 experimental program included a test to determine whether or not yellowfin tuna livers could replace beef liver in a mixed meat-gland-viscera-meal diet.

The 1950 program

The experimental program for 1950 was designed to evaluate some new feeding materials not previously tested as well as to corroborate earlier findings. Whole true cod was fed as 30 percent of a mixed diet. Halibut "sawdust", the band-saw residue resulting from preparation of steaks from frozen halibut, was included in a mixed diet as a source of protein. Continued experiments on the addition of fish meals to the diets included mackerel offal meal, a meal not previously tested. Preliminary trials on the effect of addition of two types of animal protein factor (APF) supplements to mixed diets were carried out. Also, experiments were carried out to determine the detrimental effect, if any, on salmon fingerlings of diets of salmon roe containing added preservatives.

The 1950 experimental program was modified from previous years in that two feeding periods of diet evaluation were set up. The first period of 12 weeks duration was arbitrarily designated as the cold water period because the average water temperatures in which the fish were maintained were below 50° F. The second period was designated as the warm water period because the average temperatures were above 50° F. It had been observed during previous feeding trials that if a diet proved to be inadequate during the warm water feeding period, it was definitely not suitable for cold water feeding. Dried meals which normally produced a lower growth rate than the wet products, were fed only after the water temperature had reached 50° F. By this feeding practice, it was hoped that the greater growth rate obtained during the warm water period would emphasize any measurable differences that might occur in the evaluation of the new feeding materials.

The 1950 warm-water feeding experiments (Robinson, Payne, Palmer, and Burrows 1951), confirmed the observation made during 1949 that salmon roe greatly stimulated the growth rate of salmon fingerlings. At the end of a 12-week experimental period, the weight of salmon fingerlings fed a diet of salmon roe plus 10 percent salmon viscera meal was 116 percent greater than the weight of those fed a diet of beef liver and 48 percent greater than the weight of those fed the Leavenworth "production diet", which was composed of 20 percent each of beef liver, hog liver, and hog spleen, along with 30 percent salmon viscera and 10 percent salmon viscera meal. Previously, it had been found that this "production diet" possessed the greatest growth potential for blueback fingerlings.

Salmon eggs preserved with sodium bisulfite gave the best feeding results as compared with salmon eggs preserved by other chemicals.

Besides the feeding experiments and laboratory study and analyses of feed ingredients, laboratory and commercial scale experiments were conducted during 1950 and extending into 1951, to determine the technical and economic feasibility of delivering salmon cannery waste from Alaska to fish hatcheries in the state of Washington.

A method was developed by which the salmon waste was shipped frozen in a newly designed container consisting of a burlap sack with an inner polyethylene bag liner. This new practical and economical container was approved by the steamship transportation companies serving Alaska -- previously only metal containers were acceptable. Use of the bag containers resulted in a savings in transportation costs of 1.08 cents per pound of material shipped from Petersburg, Alaska, to Seattle, Washington. By this method, frozen salmon viscera could be shipped from Petersburg to Seattle at a cost of 5.21 cents per pound (packers profit extra) as compared to 6.29 cents per pound using metal containers.

Also, progress was made toward the development of a method for preserving salmon eggs that can be used in areas where refrigeration facilities are not available.

Many basic problems concerning the nutrition of hatchery-reared salmon fingerlings remain unsolved. These must await careful scientific investigation before noteworthy achievement can be expected. The efforts to discover and evaluate new hatchery foods should be continued and increased in view of the importance of this information to the ultimate success of the entire program of artificial propagation of the Pacific salmon.

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PART II. CHEMICAL COMPOSITION OF HATCHERY FEEDS

By Neva L. Karrick* and William Clegg*

Introduction

This section of the report presents data on the composition of mixed diets and individual diet components used in feeding blueback salmon fingerlings at the Leavenworth Laboratory of the Branch of Fishery Biology, Fish and Wildlife Service. The materials were analyzed for proximate composition and for several B vitamins (riboflavin, niacin, biotin, and vitamin B_{12}). Materials fed during 1947 and 1948 were analyzed for thiamine content.

Four general groups of materials were analyzed. These included: (1) slaughterhouse waste, (2) salmon cannery waste, (3) processed fish waste, and (4) mixed diets. At present, a high percentage of slaughterhouse waste is used in hatchery feeds. The cannery waste is used to a lesser extent and was tested as a partial or a complete substitute for the slaughterhouse waste. The processed materials were tested to determine their value as possible supplements in the hatchery fish diets.

Experimental

The samples for analysis were prepared as follows: Samples from the cannery waste, the slaughterhouse wastes, and the mixed diets were disintegrated in a blender. Samples of waste materials were stored at -18°C. and samples of diet mixtures at -29°C. Samples of meal were ground as fine as possible in an attrition-type mill (figure II-1), and stored at -18°C. Maximum fineness of the grind of the meal is essential, not only to obtain a uniform sample but also to allow complete extraction of the vitamin.

Vitamin B_{12} in the fish meal samples was extracted by adding water to the sample and autoclaving the mixture at 15 pounds pressure for 1 hour. Vitamin B_{12} in tissues and mixed diets was extracted by adding water to the sample and heating to 100°C. The mixture was stirred continuously during the heating period. Riboflavin and niacin were extracted from all samples by overnight incubation of 1 gram samples with 30 milligrams each of papain and takadiastase at 37°C. and at pH 4.5. Biotin was extracted by autoclaving the samples with 6 N hydrochloric acid at 15 pounds pressure for 2 hours.

Microbiological assays were used to determine the riboflavin, niacin, biotin, and vitamin B_{12} content of the samples. The basic procedure used for the riboflavin, niacin and biotin assays was described by Roberts and Snell (1946). Stock cultures of Lactobacillus casei and Lactobacillus arabinosus were maintained on agar stabs as recommended by the Association of Agricultural Chemists (1949).

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Figure II-1. Attrition-type mill used to grind dry materials such as fish meal samples.

Vitamin B_{12} was assayed by a modification of the method of Hoffman, Stokstad, Hutchins, Dornbush, and Jukes (1949). Enzymatic-digested casein was omitted from the medium. The amount of glucose was doubled and two grams of ascorbic acid per liter of double-strength basal medium was substituted for the thioglycollic acid. The medium was adjusted to pH 5.5 before autoclaving.

The stock culture of Lactobacillus leichmannii 313 (ATCC 7830) used for the vitamin B_{12} assay was maintained on tomato juice agar. To produce the assay inoculum, the cultures were inoculated into broth tubes containing single-strength medium plus 1 percent dried whey and were incubated overnight at 37° C. One milliliter of this broth was added to 10 milliliters of sterile saline; one drop of the suspension was added to each assay tube.

Extracts of the samples were run in duplicate at four levels for each of the vitamins. Riboflavin and niacin standards were run in duplicate at 5 levels between 0.05 and 0.08 millimicrogram; and the vitamin B_{12} standard at 10 levels between 0.005 and 0.8 millimicrogram (figure II-2).

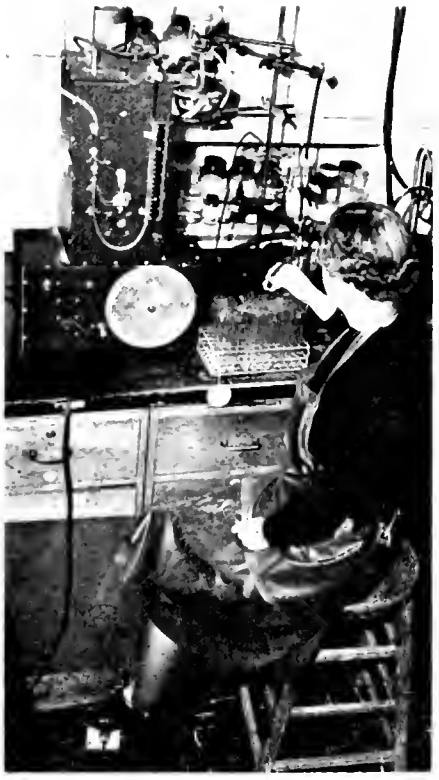

Figure II-2. Adding water to assay tubes using automatic dispenser.

the Association of Vitamin Chemists (1947).

Some of the special fish meals used in the feeding tests were prepared in the Seattle Technological Laboratory.

The methods used for preparing the various fish meals were as follows:

1. Steam-heated, vacuum-dried meals: The raw material was fed into a Stokes rotary steam-jacketed drier. Steam pressure was applied in the jacket and air was exhausted from the chamber until

The tubes containing the extracts and standards were sterilized at 15 pounds pressure for 15 minutes. The tubes were cooled and inoculated aseptically with the organism used for the vitamin being assayed. After inoculation, the tubes were incubated for 65-70 hours at 37° C. In order to stop bacterial growth at the end of this period, the tubes were heated in an autoclave until 15 pounds pressure was obtained in the chamber. The acid produced in each tube by the growth of the bacteria was titrated electrometrically with 0.1N sodium hydroxide (figure II-3).

Results of three to six assays were averaged to obtain the data reported in tables II-1, 2, 3, and 4.

The analyses for moisture, ash, protein, and fat were made by standard procedures described by the Association of Official Agricultural Chemists (1950). The thiamine content was determined by the method described by

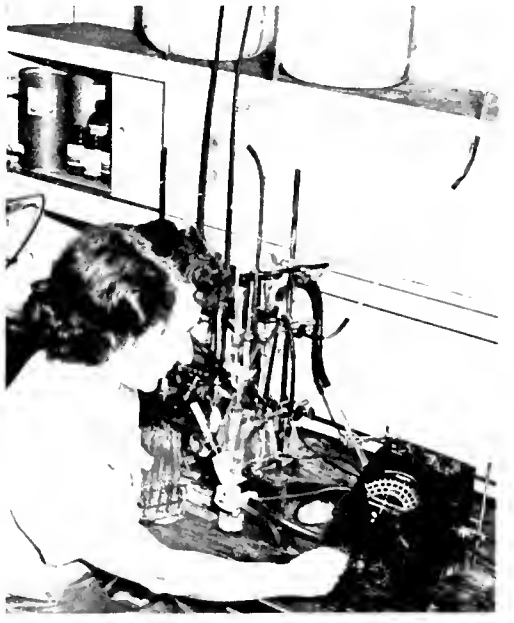

Figure II-3. Titration equipment used to determine the acid produced during the growth period.

a vacuum of 26 inches was reached. The material in the chamber was agitated mechanically during the drying process and the steam pressure controlled so that the temperature of the material did not exceed 150°F. The drying time depended upon particle size, consistency, and amount of material. Certain materials tended to stick to the blades of the agitator, thus prolonging the drying time. One hundred pounds of raw material could be processed in 6 to 12 hours. The dried scrap was ground in a Wiley mill using a 3/16-inch hole size screen.

2. Steam-cooked, air-tunnel dried meals: The raw material was spread on trays made of galvanized welded wire fabric of one-half inch mesh. The loaded trays were stacked in a basket with a conical aluminum drain plate between each tray. The basket was placed in the vertical pressure cooker, and the fish were processed at 15 pounds pressure for ten minutes. The use of spaced trays made it possible to subject the material to a uniform heat treatment, and the drain plates for each tray deflected the freed liquor and condensed steam from lower trays, thus minimizing the leaching of water-soluble materials from the cooking fish. The cooked material was spread on screens made from one-half inch mesh galvanized wire fabric, using approximately 1-1/2 pounds of material per square foot of surface. The screens were placed in a tunnel-type hot air drier. The cooked material was dried at either 100° or 150°F. for 1-1/2 to 2 hours. The dried scrap was ground in a Wiley mill using a 3/16-inch hole size screen.

3. Acetone-extracted meals: The raw material was mixed with enough acetone to precipitate the protein, approximately 4 volumes of acetone to 1 volume of raw material. After allowing the mixture to stand with occasional stirring, the acetone layer, which contained the water, oil, and possibly other acetone-soluble materials, was removed by decantation. For a second extraction, enough acetone was added to make a definite layer of liquid on top of the solid phase. The acetone remaining in the meal after decantation was allowed to evaporate at room temperature.

4. Meal from spoiled pink salmon offal: Frozen, ground Alaska pink salmon offal was placed in a large wooden box and allowed to stand in an unheated room. The experiment was conducted during the winter and the temperatures in the room were almost the same as outside, fluctuating around 50°F. The mass was stirred thoroughly at intervals in order to keep the spoiling action uniform. After two weeks the spoiled offal was cooked and dried in an air tunnel at 100°F. as described in the preparation of steam cooked air-dried meals.

5. Lyophilized meals: The raw material was finely ground and a small amount was placed in a round bottom flask. The material was frozen in a thin layer on the inside surface of the flask using dry ice and alcohol. The sample was dried by exposing it to a high vacuum which removed the moisture.

6. Flame-dried salmon offal meals: These samples were prepared commercially from whole cannery waste. The meal was dried by use of a gas, direct flame drier.

7. Blue crab (Callinectes sapidus) meal: The meal was prepared commercially in a rotary flame drier from the whole scrap of blue crab.

8. Dungeness crab (Cancer magister) meal: The commercial meal was prepared by dry-rendering Dungeness crab scrap at atmospheric pressure. The laboratory meal was prepared at the Seattle Technological Laboratory by vacuum drying the scrap in a Stokes steam-jacketed drier at a temperature of 100° to 145°F.

9. Mackerel (Pneumatophorus diego) offal meal: The mackerel meal was prepared in a commercial plant by a wet-rendering method. The press cake was dried in an air-lift drier.

Discussion of Results

Results of the feeding tests at Leavenworth are discussed in detail in several reports (Burrows and Karrick 1947; Burrows, Robinson, and Palmer 1951; Robinson, Palmer, and Burrows 1951; Robinson, Payne, Palmer, and Burrows 1951), and are summarized in Part IV of this report. Results of the vitamin and proximate analyses are given in tables II-1, 2, 3, and 4.

Although quality of protein affects the nutritive value of the diets, the results reported here are for total protein only and give no indication of any alteration that may have occurred to the protein during processing. Limited time and personnel precluded a study of protein quality.

Natural materials vary in composition. Therefore, it must be emphasized that the analyses reported are on samples which are representative of comparatively small amounts of material and are not representative of the raw material as a whole. For example, beef liver undoubtedly varies to a considerable extent from one portion to another of a lot as well as from one lot to another. The analyses of the slaughterhouse waste used in the diets were core samples taken from a single block of beef liver furnished by the hatchery and thus were representative only of that particular block of material.

One hundred percent beef liver is used as the standard diet for hatchery feeding tests. For this reason the composition of both mixed diets and the raw materials being studied as potential substitutes are compared with beef liver.

The composition of the samples of hog and beef liver examined was essentially the same. Hog spleen contained more fat, less protein, and had a much lower vitamin content than the liver products. The salmon viscera samples had a lower vitamin content than did the beef liver.

There were no significant differences in the composition of chinook salmon (Oncorhynchus tshawytscha) viscera from the Columbia River and pink

salmon (Oncorhynchus gorbusha) viscera from Puget Sound and Alaska. However, there were variations in the composition of different organs of the viscera. The eggs, which Robinson, Palmer, and Burrows (1951) found produced more growth than any other parts of the viscera, did not have a high vitamin content but contained the most protein and fat. The milt, digestive tract, and liver all contained about the same amount of protein and fat as the whole viscera. The liver and digestive tract had a higher vitamin content than either whole viscera or eggs.

Burrows, Robinson, and Palmer (1951), and Robinson, Palmer, and Burrows (1951), found that yellowfin tuna (Neothunnus macropterus) liver apparently contains anti-anemia factors and thus is of potential value as a component of hatchery diets. The protein and vitamin contents of yellowfin tuna liver were comparable to that of beef liver.

Hake (Merluccius productus), whole cod (Gadus macrocephalus), and halibut (Hippoglossus stenolepis) sawdust, each of which Robinson, Palmer, and Burrows (1951), and Robinson, Payne, Palmer, and Burrows (1951), found could be substituted for hog spleen but not for hog liver in the hatchery diets, had vitamin contents in the range of the hog spleen rather than of the hog liver. Halibut sawdust and whole cod contained less protein and considerably smaller amounts of the vitamins than did the beef liver.

With the exception of the meals prepared by acetone extraction, the vitamin contents of the salmon viscera meals were essentially the same. The acetone-extracted meal contained smaller amounts of the vitamins. However, Robinson and his co-workers (1951 (B)), found that the steam-heated, vacuum-dried viscera meals produced better growth in fish than did the viscera meals manufactured by other methods. Since no significant differences in composition were evident, the additional growth probably was due to factors other than those tested. The retention of these additional growth factors may have been due to the fact that the steam-heated, vacuum-dried meal required no precooking.

Salmon offal meals contained a slightly smaller quantity of the vitamins than the salmon viscera meals; however, the important difference was that less protein and more fat were present. The flame-dried offal meal had a lower vitamin content than did the offal meals dried in an air tunnel at 100° or 145° F.

Meal prepared from decomposed offal showed about the same proximate composition and vitamin content as the meals prepared from fresh offal.

Flame-dried mackerel offal meal and flame-dried salmon offal meal had about the same protein and vitamin contents.

The meal from blue crab, which Robinson, Palmer, and Burrows (1951) found was effective in preventing anemia and decreasing mortality in fish,

had lower amounts of vitamins and protein than did the steam vacuum-dried chinook salmon viscera meal. The blue crab meal had a higher vitamin content, more protein and fat, and less ash than the Dungeness crab meal. This difference in the proximate composition between the two types of crab meal is accounted for by the fact that the meat is removed from the Dungeness crab legs, but not from those of the blue crab.

None of the mixed diets had as high a vitamin content as the beef liver. Despite this, Burrows (1947 and 1951), Robinson (1951 A and B), and their co-workers found that several of these mixed diets resulted in better growth and lower mortality of hatchery fish than did 100 percent beef liver. This suggests that uninvestigated factors were significant.

Salmon viscera meals added to a meat-salmon viscera diet resulted in a higher percentage of protein. This higher protein content may have been a partial explanation of the additional growth response of the hatchery fish when the meat-salmon-viscera-meal combination was fed. However, crab meal also showed evidence of containing a growth factor and did not increase the protein content of the mixed diets. This also seemed to indicate that factors other than those studied may be important in the nutrition of hatchery fish.

Summary

1. Animal livers, fish viscera, and other raw materials used in hatchery-fish diets showed variation in composition among different lots of the same item.

2. The composition of hog liver and of beef liver was essentially the same.

3. The livers and the digestive tracts of salmon had higher vitamin contents than did the eggs or whole viscera; however, the eggs had the highest protein content.

4. Yellowfin tuna livers had about the same vitamin content as beef liver.

5. Acetone-extracted salmon viscera meals had a much lower vitamin content than the viscera meals prepared by other methods.

6. The salmon viscera meals contained more protein and less fat than the salmon offal meals.

7. Blue crab meal had more vitamin, protein, and fat, but less ash than the Dungeness crab meal.

8. Comparison of analytical data with results of feeding tests indicated that certain diets possessed growth factors other than those considered in this investigation.

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Table II-1.--Composition of samples of slaughterhouse waste

Sample	Sample code 1/	Proximate Composition in Percent				Vitamin Content in Micrograms per Gram					
		Moisture	Protein	Fat	Ash	Basis	Thiamine	Riboflavin	Niacin	Biotin	B_{12}
Beef liver	B	68.85	21.60	4.75	1.43	Wet	2.6	27	107	--	--
						Dry	8.3	87	343	--	--
	C	72.39	20.25	5.12	1.69	Wet	--	53	104	0.24	1.1
						Dry	--	192	377	0.87	4.0
	D	70.23	22.87	3.83	1.57	Wet	--	95	116	0.65	0.44
						Dry	--	319	390	2.18	1.48
Hog liver	B	72.05	20.42	3.33	1.35	Wet	2.4	20	112	--	--
						Dry	8.6	72	401	--	--
	C	73.81	22.19	4.10	2.05	Wet	--	53	101	0.19	0.43
						Dry	--	202	385	0.72	1.64
Hog spleen	B	75.30	16.61	6.72	1.28	Wet	1.8	3	39	--	--
						Dry	7.3	12	158	--	--
	C	69.80	16.50	14.81	1.18	Wet	--	15	29	0.01	0.03
						Dry	--	50	96	0.04	0.1

1/ All samples in this and other tables designated as A were fed during the summer of 1947, those as B during 1948, those as C during 1949, those as D in 1950, and those as E were not used in feeding tests. However, there is no significance whatever to analyses of samples used during the different years because the samples were in no way representative of the raw materials available during any one year.

Table II-2.--Composition of samples of cannery waste

Sample	Sample code [1]	Proximate Composition in Percent				Vitamin Content in Micrograms per Gram					
		Moisture	Protein	Fat	Ash	Basis	Thiamine	Riboflavin	Niacin	Biotin	B_{12}
Columbia River Chinook salmon viscera	B	75.10	20.00	4.38	1.85	Wet	0.45	11	31	--	--
						Dry	1.81	44	124	--	--
	C	77.44	22.75	4.00	2.65	Wet	--	12	23	0.04	0.06
						Dry	--	53	102	0.18	0.27
Pink salmon											
1. Alaska											
a. Viscera	B	76.45	18.05	4.56	1.49	Wet	0.60	5	25	--	--
						Dry	2.55	21	106	--	--
b. Total	B	73.75	15.25	8.09	2.90	Wet	0.55	3	24	--	--
						Dry	2.10	11	91	--	--
c. Total offal (spoiled)	B	74.40	16.24	8.94	3.44	Wet	0.50	2.5	25	--	--
						Dry	1.95	9.8	98	--	--
2. Puget Sound											
a. Viscera	B	64.00	28.50	6.72	2.20	Wet	0.35	4	11	--	--
						Dry	0.97	11	31	--	--
	C	79.08	18.37	3.77	1.51	Wet	--	20	38	0.05	0.04
						Dry	--	96	182	0.22	0.21
b. Milt	C D	81.60	18.37	1.64	2.30	Wet	--	2.4	20	0.02	0.07
						Dry	--	13	108	0.11	0.36

Table II-2.--Composition of samples of cannery waste--Continued

Sample	Sample code 1/	Proximate Composition in Percent				Vitamin Content in Micrograms per Gram					
		Moisture	Protein	Fat	Ash	Basis	Thiamine	Riboflavin	Niacin	Biotin	B_{12}
c. Digestive tract	C	82.64	16.37	2.17	1.26	Wet	--	15	26	0.05	0.82
						Dry	--	86	150	0.28	4.72
d. Liver	C	78.91	18.37	3.92	1.57	Wet	--	18	39	0.24	0.59
						Dry	--	85	185	1.14	2.80
e. Eggs	C	57.00	29.45	11.30	1.79	Wet	--	12	7	0.06	0.24
						Dry	--	28	16	0.13	0.56
Tuna liver-yellowfin	C	72.70	24.06	3.62	1.45	Wet	--	48	86	0.32	0.24
	D					Dry	--	176	315	1.17	0.92
Hake		83.95	18.37	2.06	3.14	Wet	--	3.7	13	0.02	0.013
	D					Dry	--	23	81	0.12	0.08
Halibut sawdust	D	77.22	19.94	4.38	1.90	Wet	--	5	52	0.05	0.02
						Dry	--	22	229	0.22	0.08
Whole cod	D	80.00	17.50	2.53	2.48	Wet	--	3	12	0.07	0.06
						Dry	--	15	60	0.35	0.30

1/ All samples in this and other tables designated as A were fed during the summer of 1947, those as B during 1948, those as C during 1949, those as D in 1950, and those as E were not used in feeding tests. However, there is no significance whatever to analyses of samples used during the different years because the samples were in no way representative of the raw materials available during any one year.

Table II-3.--Composition of samples of processed cannery waste

Sample	Sample code 1/	Proximate Composition in Percent				Vitamin Content in Micrograms per Gram					
		Moisture	Protein	Fat	Ash	Basis	Thiamine	Riboflavin	Niacin	Biotin	B_{12}
Stickwater concentrate (Alaska pink viscera)	B	49.40	42.60	0.36	6.07	Wet	5.0	19	143	--	--
						Dry	9.9	38	283	--	--
Lyophilized stickwater (Chinook viscera)	E	19.18	68.50	7.13	14.01	Wet	--	92	215	0.81	2.50
						Dry	--	114	266	1.00	3.10
Herring solubles	C	24.73	32.35	12.74	7.15	Wet	--	32	148	0.05	0.20
						Dry	--	44	197	0.07	0.27
Meals - from the following sources:											
Chinook viscera 2/ 7/	A	--	--	--	--	Wet	0.8	19	40	--	--
						Dry	--	--	--	--	--
Chinook viscera 2/ acetone extracted 70°F.	A	--	--	--	--	Wet	0.7	14	15	--	--
						Dry	--	--	--	--	--

Note: See Page No. 28 for explanation of footnotes.

Table II-3.--Composition of samples of processed cannery waste--Continued

Sample	Sample code [1]	Proximate Composition in Percent				Vitamin Content in Micrograms per Gram					
		Moisture	Protein	Fat	Ash	Basis	Thiamine	Riboflavin	Niacin	Biotin	B_{12}
Pink viscera [4] [6]	B	7.98	74.40	12.04	5.12	Wet	0.50	9.0	23	--	--
						Dry	0.54	9.8	25	--	--
Pink viscera [4] [5]	D	13.10	--	12.06	--	Wet	--	15.3	95	--	0.84
						Dry	--	17.6	110	--	0.97
Salmon offal (flame dried, commercial)	B	6.94	61.56	15.99	15.90	Wet	0.30	4.0	31	--	--
						Dry	0.32	4.3	33	--	--
Chinook viscera [2] (lyophilized)	E	7.87	72.62	10.74	5.04	Wet	--	66	58	0.20	0.50
						Dry	--	72	63	0.22	0.54
Chinook viscera [2] [5]	C	12.01	70.50	15.17	5.27	Wet	--	91	70	0.17	0.70
	D					Dry	--	113	79	0.19	0.79
Chinook viscera [2] [6]	C	9.40	69.25	18.73	4.98	Wet	--	61	58	0.16	0.70
						Dry	--	67	64	0.18	0.77
Chinook viscera [2] [7]	C	11.35	63.75	23.70	5.88	Wet	--	33	61	--	0.64
						Dry	--	37	69	--	0.72
Salmon offal (Flame dried, commercial)	C	9.95	64.38	12.98	15.64	Wet	--	16	42	--	0.20
						Dry	--	18	47	--	0.22

Note: See Page No. 28 for explanation of footnotes.

Table II-3.--Composition of samples of processed cannery waste--Continued

Sample	Sample code [1]	Proximate Composition in Percent				Vitamin Content in Micrograms per Gram					
		Moisture	Protein	Fat	Ash	Basis	Thiamine	Riboflavin	Niacin	Biotin	B_{12}
Chinook viscera [2] [7]	B	8.18	65.25	21.40	5.56	Wet	1.0	28	71	--	--
						Dry	1.1	30	77	--	--
Pink viscera [3] [6]	B	9.38	66.42	23.74	5.10	Wet	1.0	16	67	--	--
						Dry	1.1	18	74	--	--
Pink viscera [3] [7]	B	3.87	64.40	24.00	7.40	Wet	1.5	15	64	--	--
						Dry	1.6	16	67	--	--
Pink viscera [3] acetone extracted 70°F.	B	9.51	71.70	10.00	10.16	Wet	0.40	10	13	--	--
						Dry	0.44	11	14	--	--
Pink offal [3] [6]	B	6.93	49.10	33.06	10.43	Wet	0.70	8	63	--	--
						Dry	0.75	8.6	68	--	--
Pink offal [3] [7]	B	5.45	51.75	31.88	10.93	Wet	0.70	7	55	--	--
						Dry	0.74	7.4	58	--	--
Pink offal [3] acetone extracted 70°F.	B	10.95	69.30	6.57	13.67	Wet	0.20	5.0	14	--	--
						Dry	0.22	5.6	16	--	--
Pink offal [3] [6] (spoiled)	B	8.73	47.00	35.83	11.41	Wet	0.30	6.0	58	--	--
						Dry	0.33	6.6	64	--	--

Note: See Page No. 28 for explanation of footnotes.

Table II-3.--Composition of samples of processed cannery waste--Continued

Sample	Sample code 1/	Proximate Composition in Percent				Vitamin Content in Micrograms per Gram					
		Moisture	Protein	Fat	Ash	Basis	Thiamine	Riboflavin	Niacin	Biotin	B_{12}
Total blue crab scrap (flame dried, commercial)	C	10.11	51.56	11.58	23.63	Wet	--	85	60	0.14	0.16
	D					Dry	--	95	67	0.16	0.18
Dungeness crab 8/ scrap (dry rendered, commercial)	E	4.62	32.25	6.35	48.63	Wet	--	11	39	0.036	0.012
						Dry	--	11.5	41	0.038	0.012
Dungeness crab 8/ scrap 5/	E	5.62	32.19	0.86	41.83	Wet	--	23	33	0.06	0.06
						Dry	--	24	35	0.064	0.064
Mackerel offal (commercial)	D	7.33	55.94	7.05	30.18	Wet	--	15	39	0.09	0.15
						Dry	--	16	42	0.097	0.16

1/ All samples in this and other tables designated as A were fed during the summer of 1947, those as B during 1948, those as C during 1949, those as D in 1950, and those as E were not used in feeding tests. However, there is no significance whatever to analyses of samples used during the different years because the samples were in no way representative of the raw materials available during any one year.

2/ Chinook salmon from Columbia River.

3/ Pink salmon from Alaska.

4/ Pink salmon from Puget Sound.

5/ Steam-vacuum dried in Stokes rotary steam-jacketed drier. The maximum temperature 150° F.

6/ Dried in an air tunnel at 100° F.

7/ Dried in an air tunnel at 150° F.

8/ To obtain more complete values for the proximate composition of crab meal samples, which contain high amounts of chitin, analyses for crude fiber should be made.

Table II-4.--Composition of diets

Diet Number	DIET		Proximate Composition in Percent				Vitamin Content in Micrograms per Gram				
	Components	Percentage Composition	Moisture	Protein	Fat	Ash	Basis	Riboflavin	Niacin	Biotin	B_{12}
1 and 19	Beef liver	100	70.23	22.87	3.83	1.57	Wet Dry	95 319	116 390	0.65 2.18	0.44 1.48
2	Beef liver Hog liver Hog spleen Salmon viscera	22.2 22.2 22.2 33.4	74.05	20.44	6.12	1.45	Wet Dry	50 193	76 293	app.0.4 [1] 1.54	0.29 1.12
3 and 46	Beef liver Hog liver Hog spleen Salmon viscera Salmon viscera meal	20.0 20.0 20.0 30.0 10.0	68.39	25.56	6.56	1.99	Wet Dry	45 142	79 250	0.45 1.42	0.37 1.17
4	Beef liver Hog liver Hog spleen Salmon viscera Crab meal	21.1 21.1 21.1 31.7 5.0	71.26	20.25	6.76	3.43	Wet Dry	57 198	65 226	0.48 1.67	0.34 1.18
5	Beef liver Hog liver Hog spleen Salmon viscera Crab meal Salmon viscera meal	19.0 19.0 19.0 28.0 4.5 10.0	66.90	25.00	6.69	3.35	Wet Dry	-- --	-- --	-- --	-- --

Table II-4.--Composition of diets--Continued

Diet Number	DIET		Proximate Composition in Percent				Vitamin Content in Micrograms per Gram				
	Components	Percentage Composition	Moisture	Protein	Fat	Ash	Basis	Riboflavin	Niacin	Biotin	B_{12}
6	Beef liver	22.2									
	Hog liver	22.2									
	Hog spleen	22.2									
	Salmon eggs	33.4	67.10	24.06	8.45	1.54	Wet	29	52	0.41	0.42
							Dry	88	158	1.25	1.28
7 and 25	Beef liver	20.0									
	Hog liver	20.0									
	Hog spleen	20.0									
	Salmon eggs	30.0									
	Salmon viscera meal	10.0	62.62	28.50	5.75	1.98	Wet	30	51	0.49	0.35
							Dry	80	136	1.31	0.94
8	Beef liver	33.3									
	Hog liver	33.3									
	Salmon viscera	33.4	74.30	21.22	3.86	1.45	Wet	47	59[1/]	0.58	0.44
							Dry	183	230	2.26	1.71
9	Beef liver	30.0									
	Hog liver	30.0									
	Salmon viscera	30.0									
	Salmon viscera meal	10.0	66.84	26.87	6.17	2.06	Wet	--	--	--	--
							Dry	--	--	--	--
10	Beef liver	30.0									
	Hog liver	30.0									
	Salmon viscera	30.0									
	Salmon milt	10.0	74.41	21.09	4.82	1.57	Wet	44	58[1/]	0.5	0.43
							Dry	172	227	1.95	1.68

1/ These results were not good averages.

Table II-4.--Composition of diets--Continued

Diet Number	D I E T		Proximate Composition in Percent				Vitamin Content in Micrograms per Gram				
	Components	Percentage Composition	Moisture	Protein	Fat	Ash	Basis	Riboflavin	Niacin	Biotin	B_{12}
11	Beef liver	27.0									
	Hog liver	27.0									
	Salmon viscera	27.0									
	Salmon milt	9.0									
	Salmon viscera meal	10.0	67.15	26.87	5.77	2.18	Wet	--	--	--	--
							Dry	--	--	--	--
12	Beef liver	30.0									
	Hog liver	30.0									
	Salmon eggs	30.0									
	Salmon milt	10.0	67.93	24.44	7.30	1.70	Wet	--	--	--	--
							Dry	--	--	--	--
13	Beef liver	27.0									
	Hog liver	27.0									
	Salmon eggs	27.0									
	Salmon milt	9.0									
	Salmon viscera meal	10.0	63.77	28.87	8.00	2.10	Wet	--	--	--	--
							Dry	--	--	--	--
14	Beef liver	15.0									
	Salmon viscera	85.0	76.54	19.87	4.75	1.41	Wet	7	28	0.21	0.22
							Dry	30	119	0.90	0.94
15	Beef liver	15.0									
	Salmon viscera	83.0									
	Yeast	2.0	76.14	19.94	5.03	1.67	Wet	15	30	0.24	0.23
							Dry	63	126	1.01	0.96

Table II-4.--Composition of diets--Continued

Diet Number	D I E T		Proximate Composition in Percent				Vitamin Content in Micrograms per Gram				
	Components	Percentage Composition	Moisture	Protein	Fat	Ash	Basis	Riboflavin	Niacin	Biotin	B_{12}
16	Hog liver	15.0									
	Salmon viscera	85.0	78.20	19.25	3.55	1.47	Wet	8	28	0.18	0.17
							Dry	37	128	0.83	0.77
17	Beef liver	7.5									
	Hog liver	7.5									
	Salmon viscera	85.0	78.44	19.13	4.20	1.50	Wet	6	18	0.16	0.26
							Dry	28	83	0.74	1.21
18	Beef liver	15.0									
	Hog liver	15.0									
	Salmon viscera	70.0	77.26	19.69	4.76	1.58	Wet	17	37	0.35	0.2
							Dry	75	163	1.54	0.87
20	Salmon eggs (frozen)	90.0									
	Salmon viscera meal	10.0	54.21	31.56	9.58	2.44	Wet	11	13	0.3	0.36
							Dry	24	28	0.66	0.79
21	Preserved salmon eggs (2 percent sodium benzoate and 2 percent salt)	90.0									
	Salmon viscera meal	10.0	53.80	29.94	8.10	3.62	Wet	--	--	--	--
							Dry	--	--	--	--

Table II-4.--Composition of diets--Continued

Diet Number	D I E T		Proximate Composition in Percent				Vitamin Content in Micrograms per Gram				
	Components	Percentage Composition	Moisture	Protein	Fat	Ash	Basis	Riboflavin	Niacin	Biotin	B_{12}
22	Preserved salmon eggs (1 percent sodium benzoate and 0.1 percent sodium bisulfite and 2 percent salt)	90.0									
	Salmon viscera meal	10.0	53.19	31.00	2.43	3.45	Wet	--	--	--	—
							Dry	--	--	--	--
23	Preserved salmon eggs (0.5 percent sodium bisulfite)	90.0									
	Salmon viscera meal	10.0	56.5	30.30	8.45	2.27	Wet	9	13	0.31	0.54
							Dry	21	30	0.71	1.24
24	Preserved salmon eggs (0.2 percent sodium bisulfite and 2 percent salt)	90.0									
	Salmon viscera meal	10.0	53.06	31.25	9.28	3.32	Wet	--	--	--	--
							Dry	--	--	--	--

Table II-4.--Composition of diets--Continued

Diet Number	D I E T		Proximate Composition in Percent				Vitamin Content in Micrograms per Gram				
	Components	Percentage Composition	Moisture	Protein	Fat	Ash	Basis	Riboflavin	Niacin	Biotin	B_{12}
26	Beef liver	20.0									
	Hog liver	20.0									
	Hog spleen	20.0									
	Preserved salmon eggs (2 percent sodium benzoate and 2 percent salt)	30.0									
	Salmon viscera meal	10.0	61.78	28.44	8.94	2.42	Wet	--	--	--	--
							Dry	--	--	--	--
27	Beef liver	20.0									
	Hog liver	20.0									
	Hog spleen	20.0									
	Preserved salmon eggs (1.0 percent sodium benzoate and 0.1 percent sodium bisulfite and 2 percent salt)	30.0									
	Salmon viscera meal	10.0	63.10	26.70	7.98	2.23	Wet	--	--	--	--
							Dry	--	--	--	--

Table II-4.--Composition of diets--Continued

Diet Number	DIET		Proximate Composition in Percent				Vitamin Content in Micrograms per Gram				
	Components	Percentage Composition	Moisture	Protein	Fat	Ash	Basis	Riboflavin	Niacin	Biotin	B_{12}
28	Beef liver	20.0									
	Hog liver	20.0									
	Hog spleen	20.0									
	Preserved salmon eggs (0.5 percent sodium bisulfite)	30.0									
	Salmon viscera meal	10.0	62.60	28.75	9.09	2.11	Wet	24	34	0.42	0.39
							Dry	64	91	1.12	1.04
29	Beef liver	20.0									
	Hog liver	20.0									
	Hog spleen	20.0									
	Preserved salmon eggs (0.2 percent sodium bisulfite and 2 percent salt)	30.0									
	Salmon viscera meal	10.0	62.5	28.94	8.20	2.29	Wet	--	--	--	--
							Dry	--	--	--	--
30	Salmon viscera	50.0									
	Hake	40.0									
	Salmon viscera meal	10.0	73.2	24.00	4.59	2.43	Wet	7	18	0.14	0.29
							Dry	26	67	0.52	1.08

Table II-4.--Composition of diets--Continued

Diet Number	DIET		Proximate Composition in Percent				Vitamin Content in Micrograms per Gram				
	Components	Percentage Composition	Moisture	Protein	Fat	Ash	Basis	Riboflavin	Niacin	Biotin	B_{12}
31	Salmon viscera	50.0									
	Hake	40.0									
	Salmon viscera meal	10.0	72.80	23.25	4.97	2.84	Wet	10	20	0.12	0.36
	APF supplement						Dry	37	74	0.44	1.32
32	Beef liver	25.0									
	Hog spleen	25.0									
	Canned salmon	45.0									
	Salmon viscera meal	5.0	68.95	24.38	7.57	2.38	Wet	19	56	0.29	0.25
							Dry	61	180	0.93	0.80
33	Beef liver	25.0									
	Hog spleen	25.0									
	Canned salmon	45.0									
	Salmon viscera meal	5.0	68.51	24.62	7.13	2.60	Wet	21	52	0.37	0.24
	APF supplement (Lederle)						Dry	67	165	1.17	0.76
34	Beef liver	22.2									
	Hog liver	22.2									
	Hake	22.2									
	Salmon viscera	33.4	76.45	19.62	4.67	1.70	Wet	--	--	--	--
							Dry	--	--	--	--

Table II-4.--Composition of diets--Continued

Diet Number	D I E T		Proximate Composition in Percent				Vitamin Content in Micrograms per Gram				
	Components	Percentage Domposition	Moisture	Protein	Fat	Ash	Basis	Riboflavin	Niacin	Biotin	B_{12}
35	Beef liver	20.0									
	Hog liver	20.0									
	Hake	20.0									
	Salmon viscera	30.0									
	Salmon viscera meal	10.0	70.55	25.31	5.67	2.34	Wet	27	36	0.3	0.29
							Dry	92	122	1.02	0.98
36	Beef liver	20.0									
	Hog liver	20.0									
	Hake	20.0									
	Salmon viscera	30.0									
	Salmon milt	10.0	76.40	19.62	4.36	1.84	Wet	--	--	--	--
							Dry	--	--	--	--
37	Beef liver	18.0									
	Hog liver	18.0									
	Hake	18.0									
	Salmon viscera	27.0									
	Salmon milt	9.0									
	Salmon viscera meal	10.0	70.15	25.69	5.76	2.33	Wet	--	--	--	--
							Dry	--	--	--	--
38	Beef liver	20.0									
	Hog liver	20.0									
	Hake	20.0									
	Salmon eggs	30.0									
	Salmon milt	10.0	70.00	23.62	5.38	2.00	Wet	--	--	--	--
							Dry	--	--	--	--

Table II-4.--Composition of diets--Continued

Diet Number	DIET		Proximate Composition in Percent				Vitamin Content in Micrograms per Gram				
	Components	Percentage Composition	Moisture	Protein	Fat	Ash	Basis	Riboflavin	Niacin	Biotin	B_{12}
39	Beef liver	18.0									
	Hog liver	18.0									
	Hake	18.0									
	Salmon eggs	27.0									
	Salmon milt	9.0									
	Salmon viscera meal	10.0	64.64	28.75	7.51	2.52	Wet	--	--	--	--
							Dry	--	--	--	--
40	Tuna liver	20.0									
	Hog liver	20.0									
	Hog spleen	20.0									
	Salmon viscera	30.0									
	Salmon viscera meal	10.0	69.83	26.12	6.02	1.98	Wet	28	41[1/]	0.29	0.28
							Dry	93	136	0.96	0.93
41	Whole cod	100.0	80.00	17.50	2.53	2.48	Wet	3	12	0.07	0.06
							Dry	15	60	0.35	0.30
42	Beef liver	20.0									
	Hog liver	20.0									
	Whole cod	20.0									
	Salmon viscera	30.0									
	Salmon viscera meal	10.0	70.55	25.00	5.93	2.26	Wet	27	44	0.37	0.29
							Dry	92	149	1.26	0.98

1/ These results were not good averages.

Table II-4.--Composition of diets--Continued

Diet Number	D I E T		Proximate Composition in Percent				Vitamin Content in Micrograms per Gram				
	Components	Percentage Composition	Moisture	Protein	Fat	Ash	Basis	Riboflavin	Niacin	Biotin	B_{12}
43	Halibut sawdust	100.0	77.22	19.94	4.38	1.90	Wet Dry	5 22	52 229	0.05 0.22	0.02 0.08
44	Beef liver Hog liver Halibut sawdust Salmon viscera Salmon viscera meal	20.0 20.0 20.0 30.0 10.0	70.45	25.19	6.52	2.00	Wet Dry	28 95	46 156	0.32 1.08	0.17 0.57

1/ These results were not good averages.

PART III. CHEMICAL PRESERVATION OF SALMON EGGS FOR FISH HATCHERY FEED

By George Pigott* and M. E. Stansby**

Introduction

Alaskan salmon cannery waste is available in large quantities at a considerable number of canneries which are not equipped with mechanical refrigeration. Where refrigeration is available, freezing is the best method of preserving the waste for subsequent hatchery use. Where no freezing facilities are available, the most promising possibility would seem to be the development of some simple, chemical preservative which could be applied to the waste.

Many attempts have been made in the past to develop an effective, cheap chemical preservative for fish waste. When the waste contains all the visceral portions of the fish, the problem is not a simple one since it is not only necessary to stop the action of the bacteria but also that of the very active enzymes present in the digestive system of the fish. Usually, the problem of inactivation of these digestive enzymes is more difficult to overcome than retarding the action of spoilage bacteria. Frequently, success can be achieved only by some drastic treatment whereby the chemical nature of the entire raw material is considerably altered. Such extensive changes would probably prove to be undesirable if the preserved product were to be used for fish hatchery feed because the chemical alteration probably would decrease the nutritive value of the product by destroying vitamins or by rendering them or other nutritive components less digestible.

With these considerations in mind, it was decided to concentrate efforts toward preservation of the segregated salmon eggs rather than on the entire visceral portion of the waste. Previous tests comparing the nutritive value of salmon eggs with salmon viscera had shown that the former was far superior. Since salmon eggs contain no digestive enzymes, it was felt that there was a far better chance of developing a chemical preservative for the eggs than for the entire viscera.

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Laboratory Tests

Several hundred chemicals and combinations of chemicals were tested in the laboratory to determine which showed suitable preserving properties. In these preliminary tests the various chemicals were mixed with small quantities of salmon eggs in glass jars and the samples stored at room temperature. Observations made at intervals eliminated most of the chemicals from consideration because of lack of preservative action, adverse effect on texture, or because excessive amounts of an expensive chemical were required. After taking into account the cost of the chemicals which gave promising results the list was reduced to only three -- sodium bisulfite, sodium benzoate, and sodium chloride. Large concentrations of sodium chloride (salt) gave good preservation but the texture of the eggs was adversely affected. About 2 percent salt is generally added to the final diet of hatchery fish so this amount could be added initially to the eggs along with other preservatives to give possible additional preservation.

The laboratory experiments indicated that 0.5 percent sodium bisulfite based on the weight of the eggs (0.5 pound of preservative per 100 pound eggs) gave good preservation for several months. There was some indication that with 2 percent sodium chloride present the bisulfite concentration could be lowered to 0.2 percent. It was desirable to keep the bisulfite concentration at as low a level as possible because of its tendency to destroy thiamine.

Pilot-Plant-Scale Tests

Pilot-plant-scale preservation tests of several hundred pound lots of salmon eggs were made in commercial salmon canneries both on Puget Sound, Washington, and Ketchikan, Alaska, during the summer of 1950. The test lots of eggs were preserved in 110-pound metal drums, in friction top 30-pound "berry tins" and in hermetically sealed No. 10 cans. Eggs were put up with sodium bisulfite, and with sodium chloride, using two formulae-- 0.5 percent $NaHSO_3$ and 0.2 percent $NaHSO_3$ with 2.0 percent NaCl.

Those eggs treated with chemicals containing 2 percent salt had a tendency, upon storage, to liquefy. The eggs stored in hermetically sealed tinned containers kept especially well. When the non-hermetically sealed containers were used, a small layer of mold formed in some cases and after prolonged storage some small amount of spoilage had taken place.

Hatchery Fish Feeding Tests

Feeding tests on hatchery fish were carried out using salmon eggs treated with various chemical preservatives. The purpose of these feeding experiments was to determine the effect, if any, of these chemical additives on hatchery fish. Feeding tests were started in April 1950. Hatchery fish are available only in the early part of the year; however, at this time of

the year salmon cannery waste is not available. Therefore, in order to carry out these tests, it was necessary to use frozen salmon eggs from the previous season's pack. The frozen eggs were thawed; the chemicals added to and thoroughly mixed with the eggs; the mixture was allowed to stand at room temperature for two days; and then the treated eggs were re-frozen and used as needed in the feeding tests. The eggs were re-frozen as a matter of convenience in handling, since the purpose of these feeding tests was not to determine the efficiency of the preservatives, but rather to determine whether or not the chemical additives were toxic to the fish.

Four preservative treatments were tried:

a. Sodium benzoate, 2 percent, and sodium chloride, 2 percent.

b. Sodium benzoate, 1 percent; sodium bisulfite, 0.1 percent; and sodium chloride, 2 percent.

c. Sodium bisulfite, 0.5 percent.

d. Sodium bisulfite, 0.2 percent, and sodium chloride, 2 percent.

Commercial-Scale Tests

During the summer of 1951 a semi-commercial-scale lot of chemically preserved salmon eggs was put up at a cannery in Petersburg, Alaska. In this experiment 5,000 pounds of eggs were preserved with 0.5 percent sodium bisulfite in 30-pound tinned berry cans with friction-top lids. These eggs were then shipped from Petersburg to Seattle by regular commercial steamship and transported to the Federal fish hatchery at Leavenworth, Washington. When the shipment arrived at Leavenworth the eggs were examined by laboratory personnel and found to be partly liquefied and badly spoiled with a strong hydrogen sulfide odor present. These results were contrary to those obtained in the preceeding experiments. An explanation for this lack of keeping quality of the treated eggs may lie in the difference in handling the eggs at the plant. At the Petersburg cannery the waste was flumed with sea water; at the other canneries, where the salmon eggs were obtained for the previous year's tests, the eggs were flumed with fresh water. It is possible that enough salt from the sea water penetrated the eggs and peptized the protein, rendering the material more susceptible to spoilage.

Careful cost records during the 1951 collection showed that salmon eggs preserved with sodium bisulfite (0.5 percent by weight of the eggs) could be delivered to Seattle at a cost of 7.15 cents per pound as compared with 7.75 cents per pound required to deliver the eggs to Seattle in a frozen condition (see Part V).

Summary

Laboratory and pilot-plant-scale tests show promise for the use of sodium bisulfite as a preservative for salmon eggs for hatchery-fish feeding. A semi-commercial-scale preservation test of salmon eggs treated with sodium bisulfite was inconclusive, owing possibly to the absorption of salt by the eggs in the plant fluming operations. Another commercial-scale test is warranted.

Sodium bisulfite, when incorporated as 0.5 percent by weight of salmon eggs, is non-toxic to hatchery-reared fish.

PART IV. SUMMARY OF FEEDING TRIALS ON UTILIZATION OF FISHERY PRODUCTS FOR FISH FOOD

By Roger E. Burrows,* Leslie A. Robinson,** and David D. Palmer*

Introduction

From 1947 to 1950 the Fish and Wildlife Service conducted a series of cooperative investigations to determine the value of fishery products for the rearing of salmon. The Seattle Fishery Technological Laboratory, Branch of Commercial Fisheries, procured, prepared, and analyzed the various products used. The Leavenworth Laboratory, Branch of Fishery Biology, conducted the feeding trials.

The investigations were concerned primarily with the utilization of products either unfit or undesirable for human consumption with the primary emphasis on the utilization of salmon cannery waste products. The methods of preparation, and vitamin and proximate analysis of the products tested have been described in Part II of this report and previously by Dassow (1948) and Karrick and Edwards (1948). The 1947 feeding trials concerned specifically with evaluations of salmon waste were reported by Burrows and Karrick (1947). A report of the feeding trials conducted at the Leavenworth Laboratory from 1944 to 1948 (Burrows, Robinson, and Palmer 1951) includes the tests conducted on fishery products. Robinson, Palmer, and Burrows (1951) reported on the 1949 trials and Robinson, Payne, Palmer, and Burrows (1951) on the 1950 trials. These reports include the evaluations of the various fishery products tested but also include other problems not concerned specifically with this phase of the investigation.

The purpose of the present paper is to summarize the results of the feeding trials on the utilization of fishery products. Each product tested will be reported separately but no attempt will be made to include substantiating evidence to support the conclusions. The necessary data are included in the overall reports of the various feeding trials previously mentioned.

Methods

The methods used in the feeding trials have been described by Burrows et al.(1951). The techniques (figures IV-1, 2, 3, and 4) were the same throughout the series of experiments. To summarize briefly: All tests were conducted using blueback salmon (Oncorhynchus nerka) as the test animals. Each trial was conducted on duplicate lots of fish, and an analysis of variance for paired lots (Snedecor 1946) was used to determine the significance of differences.

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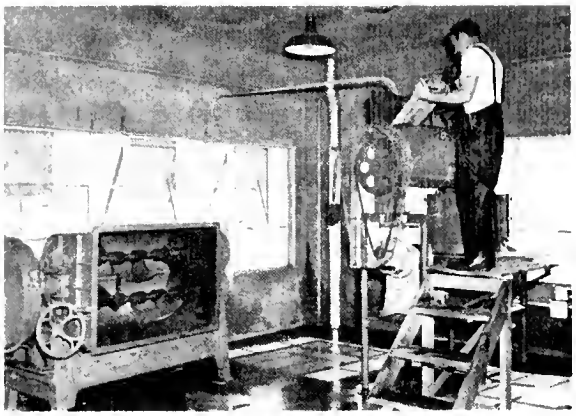

Figure IV-1. Grinding frozen block of salmon viscera for hatchery feed.

Figure IV-2. Mixing experimental fish feed.

Figure IV-3. Feeding experimental hatchery fish by means of a ricer.

Figure IV-4. Weighing experimental hatchery fish.

Summary of Results

The fishery products tested included salmon waste materials, miscellaneous raw fish products either unfit or undesirable for human consumption, and fish meals.

Salmon waste products

The primary emphasis in these investigations was placed on the utilization of salmon waste products. Salmon offal; segments of the offal-salmon viscera and salmon trimmings; segments of the viscera-milt, eggs, gastro-intestinal tract, and liver; salmon carcass; and condemned canned salmon were evaluated.

Offal

Salmon offal, the entire waste from the cannery containing the heads, tails, fins, and viscera, produced poor growth and permitted indications of vitamin deficiencies in the fish. Fish fed 90 percent salmon offal and 10 percent salmon meal produced symptoms of a pantothenic acid deficiency after 10 weeks of feeding.

Trimmings

Salmon trimmings, the offal minus the viscera, when fed at the 100 percent level in the diet, was an unsatisfactory ration. The fish grew very poorly and developed an acute anemia after 12 weeks of feeding.

Viscera

Salmon viscera, containing the milts, eggs, gastro-intestinal tract, and a portion of the liver, offered the most promise of the salmon waste products tested as a diet component. The results of the feeding trials indicated that salmon viscera produced an excellent growth response in blueback salmon, superior to any meat product tested, but was a less potent source of the anti-anemic factor than was beef liver. Salmon viscera contained but minimal amounts of pantothenic acid, sufficient only to support blueback salmon when the food intake was high. Salmon viscera, therefore, should be fed in conjunction with other products, which will supply adequate vitamin fortification, particularly during periods of cold water temperature.

Segments of the Viscera

The trials with salmon eggs, salmon milt, the gastro-intestinal tract, and salmon liver fed as the single raw components of separate diets indicates that the principal growth factor of the viscera was contained in the eggs. All of these diets when fed at cold water temperatures permitted vitamin deficiencies in the fish. The symptoms of a riboflavin deficiency were in evidence and were confirmed by the low content of the vitamin found in the food. These deficiencies disappeared during warm water feeding

when the food intake was high. The growth response to salmon eggs during warm water periods exceeded that of the salmon viscera control fish. The growth rate of the fish fed the other segments of the viscera was definitely inferior to those fed the entire viscera.

Salmon eggs in composite diets in which beef and hog liver were used to supply vitamin fortification produced gains significantly greater than those resulting from comparable diets including salmon viscera at water temperatures above 50° F.

Salmon eggs were preserved with sodium benzoate, sodium bisulfite, salt, and various combinations of these three preservatives. No toxicity to fish was demonstrated by any of the preservatives, although a destruction of thiamine was indicated. Growth of the fish when these eggs were fed at the 90-percent level in the diet was significantly greater than for any group fed the other types of preserved eggs tested and most nearly approached that of the control group fed frozen salmon eggs. Adequate fortification of diets with beef liver, hog liver, and hog spleen produced gains in weight of fish fed a 30-percent level of sodium bisulfite preserved eggs comparable to those fed the same level of frozen salmon eggs. These evaluations were preliminary in nature due to the fact that the toxicity of the chemicals rather than the effect of prolonged preservation was under investigation.

Salmon milt was found to be an excellent binding agent when mixed with salt. Its binding quality was approximately twice that of hog spleen. When used at the 10-percent level in composite diets, the feeding consistency of the ration was excellent. Salmon milt at the 10-percent level in combination with beef liver, hog liver, and salmon viscera produced excellent growth and low mortality. In a similar combination with salmon eggs substituted for viscera there was a significant increase in mortality during cold water feeding.

Salmon Carcass

The carcasses of spawned out salmon when fed in conjunction with beef and hog liver, and hog spleen, produced a growth rate inferior to comparable diets in which salmon viscera was substituted. Salmon carcasses were deficient in the anti-anemic factor as well as other essential vitamins. There were indications that the salmon carcasses contained at least small amounts of thiaminase. Although the growth response with a diet of 30-percent carcasses was less than that with an equal quantity of viscera, it still has possibilities in hatchery diets. Because of the presence of thiaminase and its deficiency in the anti-anemic factor, salmon carcasses must be adequately fortified in composite diets and fed with caution.

Canned Salmon

Condemned (unfit for human consumption) canned salmon did not compare favorably with salmon viscera when included at levels of 45 percent or over

in the diet. It produced poor growth in the fish and its anti-anemic properties were low. At least 25 percent of beef liver must be included to combat the anemia of the fish when canned salmon is fed at 45-percent level or more in the diet.

Miscellaneous raw fish products

Numerous species of fish taken in the commercial fishery have no ready market for human consumption. In addition, certain methods of preparing fishery products for the retail trade produce large amounts of waste material. Both the scrap fish and waste materials offer a source of cheap available fish food. Of these products, hake, cod, halibut sawdust, rockfish, tuna viscera, and tuna liver have been evaluated to determine their possibilities as food for salmon and trout.

Hake

Hake (Marluccius productus) were used in a series of extensive tests with various composite diets. The results indicated that hake, although deficient in the anti-anemic factor, produced a growth rate about comparable to diets containing hog spleen but inferior to those containing salmon viscera. Hake appears to be particularly adapted to cold water feeding in that the growth response of the fish to adequately fortified diets containing 20 percent hake is proportionately greater at temperatures of 50° or lower. Hake offers a cheap source of protein in diets for salmon.

Cod

Cod (Gadus macrocephalus) produced a growth response comparable to hake when fed in similar diets. The indications are that cod and hake may be used interchangeably.

Halibut Sawdust

Halibut (Hypoglossus stenolepis) sawdust, the bandsaw waste resulting from the preparation of halibut steaks for the retail market, permitted a growth rate superior to either hake or cod when fed at the 20-percent level in comparable diets at water temperatures above 50°F. Although this product is not in abundant supply, it is a cheap source of excellent protein when available.

Rockfish

Rockfish, a term used to define several species of the genus Sebastodes, when fed either whole or as the fillet waste produced a rate of growth definitely inferior to hake. These products offer little possibility in diets for salmon.

Tuna Viscera

The viscera from yellowfin tuna (Neothunnus macropterus) when included in various composite diets proved very unsatisfactory. In every instance the growth response was poor and an acute anemia developed. Surprisingly enough these anemias developed with diets which were considered to be amply fortified with beef liver (20 percent).

Tuna Liver

Tuna liver as the sole diet component produced very low growth rate but contained sufficient of the anti-anemic factor to support blueback salmon for a 24-week period. When substituted for beef liver in the standard meat-viscera-meal mixture, no anemia developed and good growth was maintained during a 12-week, warm water, feeding trial. Tuna liver offers a possible substitute for beef liver in composite diets at least during periods of warm water.

Fish meals

The investigations with fish meals were confined, with two exceptions, to evaluations of salmon waste products. In these experiments, the effect of source of the meal and method of preparation were explored. Each meal was added at the 10-percent level to a combination of 20 percent each of beef liver, hog liver, and hog spleen, and 30 percent salmon viscera.

Diets containing salmon viscera meals were found to produce greater rate of growth than those containing salmon offal meals. Vacuum-dried meals produced better growth response than did tunnel-dried meals, and the tunnel-dried meals were superior to flame-dried products.

Any of these meals, when incorporated in composite diets at the 10-percent level or over, resulted in an increased mortality and poor rate of growth when fed during prolonged periods of cold water (45°F). At water temperatures of 50°F. or over any of the salmon waste meals made a significant contribution to the growth rate of the fish with no deleterious effects.

Commercial mackerel offal meal dried by the air-lift process proved inferior to vacuum-dried salmon viscera meal but was comparable to commercially prepared, flame-dried, salmon offal meal.

Flame-dried crab meal derived from the total scrap of the blue crab (Callinectes sapidus) proved to be inferior to salmon waste meals when fed during warm water but produced none of the deleterious effects noted in salmon waste meals during periods of cold water.

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PART V. UTILIZATION OF ALASKA SALMON CANNERY WASTE AS A SOURCE OF FEED FOR HATCHERY FISH

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and M. E. Stansby****

Introduction

Research toward utilization of Alaska salmon cannery waste has been carried out since 1947 by the U. S. Fish and Wildlife Service. Particular emphasis has been placed on utilization of visceral portions of the waste as a feed for hatchery fish and on the use of the whole waste or the waste excluding heads for fur-animal food. This research has shown that the waste and the soft visceral parts, in particular, are an excellent source of protein and vitamins and that much of the vitamin content and the best protein are concentrated in the fish eggs. In developing a practical method of utilizing these materials from Alaska salmon canneries, several problems had to be overcome.

Transportation charges from Alaska are an important item in the over-all cost of collection and delivery of such material to potential users. Transportation companies have insisted that salmon offal would be acceptable for transportation only if it were packed in metal containers. This, in effect, would virtually double the freight on such materials, because the cost for shipping the empty containers to Alaska would approximately equal the cost of returning the filled containers (of course, the freight rate for any frozen material on the return shipping would be slightly higher). Experiments with different types of containers resulted in development of a method of bagging the salmon waste in an inner plastic (polyethylene) bag with an outer burlap bag. Laboratory tests indicated that such a container would withstand the bagging and freezing operations and the subsequent rough handling that it would normally encounter.

Another problem that had to be overcome was the development of a practical method for the separation of the soft visceral portion and of the eggs alone from the entire waste. The waste as it comes from the "iron chink" contains heads, tail portions, fins, viscera, and eggs. Preliminary observations made at canneries during the summer of 1950 indicated that several approaches to the problem were possible. However, the most desirable method, if feasible, would involve complete mechanical

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separation right at the chink--such that the desired, soft visceral portions might be diverted separately from the other waste onto a packing table. This would avoid any costly hand separation of the individual constituents of the waste.

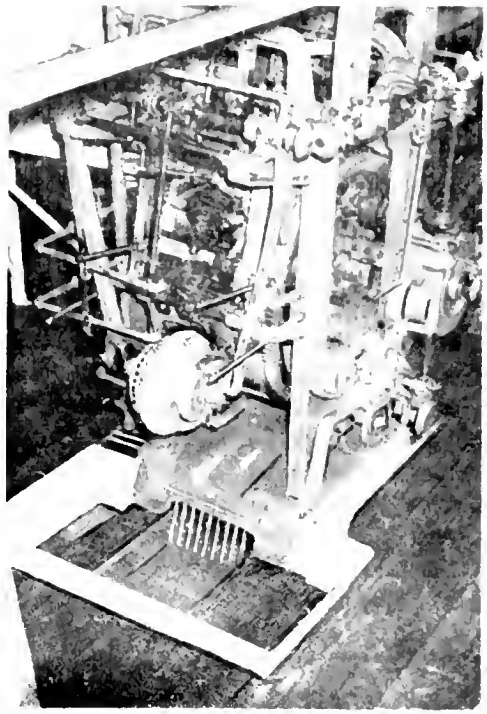

Figure V-1. Rear view of iron chink shows the grate in the floor through which the viscera were diverted into a wooden chute underneath the cannery floor.

Commercial-Scale Test

A large-scale collection of approximately 100,000 pounds of frozen salmon viscera and 3,000 pounds of frozen salmon eggs was made at Petersburg, Alaska, during the summer of 1951. The purpose of this collection was to test out on a commercial scale the feasibility of bagging and freezing viscera and to demonstrate to the commercial transportation concerns that such materials could be successfully handled in this way. This would possibly clear the way for a change in the regulations to allow shipment in bags rather than in cans, since use of cans is not economically feasible. The materials collected are being used by Fish and Wildlife Service hatcheries in the state of Washington for regular fish feeding. Careful records were kept of all costs involved in the collection so that in the future some basis would be available for estimating such costs for even larger scale operations. It was anticipated that if the collection of the salmon waste for use in fish hatcheries proved to be economically feasible, a much larger potential market (a feed for fur-bearing animals) would be opened up and that many millions of pounds of such materials might be marketed each year.

Details concerning the laboratory research on this project will be published at a later date. The balance of this report deals with results of the large-scale collection of salmon viscera and eggs at Petersburg, Alaska, during August 1951.

Installation of Equipment and Collection of Waste

After consultation with operators of the cannery at Petersburg, shields were devised and installed at the rear of the iron chink to separate the viscera from the bony portions of the salmon waste. Besides the shields, the following equipment was installed at the cannery: A gurry chute, 10 by 10 inches by 60 feet; a work platform, 12 by 20 feet, located 7 feet below the dock level; a draining table, 8 feet by 29 inches, made of 2 by 4 inch pieces placed on edge and spaced three-eighths of an inch apart; and a slide,

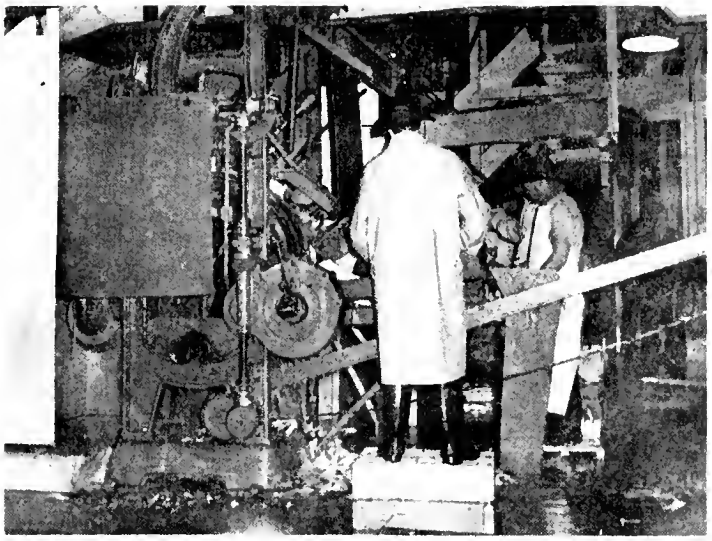

Figure V-2. Side view of iron chink. Shows (at left) the shield built around the viscera grate and (lower center) the fins piled over the fin grate.

15 feet long, from the surface of the dock to the work platform, on which an elevator moved.[1/]

By means of shields (figures 1 and 2) installed at the rear of the Iron Chinks, the viscera were diverted through a grate in the floor of the cannery into a wooden chute (10 by 10 inches by 60 feet) installed underneath the cannery floor. The viscera were carried down the chute by water from the sprays on the chinks onto the draining table. A series of trap doors installed in the chute was used to control the rate of flow. As the viscera from the three chinks, with much excess water, flowed onto the draining table (figure 3), any undesirable portions were picked out and discarded. Four men were necessary for the operation. One man controlled the flow and raked the viscera down the sloped table (sloped approximately 6 inches in 8 feet) to the second man (figure 4), who sacked the drained material (figure 5). The filled sack was passed to the third man, who knotted the top of the polyethylene bag and wire-tied the outside burlap bag (figure 5). The secured sack was then placed on the elevator (figure 6). The fourth man hand-winched the loaded elevator (six sacks) up to dock level, removed the sacks, and returned the elevator to the platform. The fourth man also made up

Figure V-3. Draining table. Viscera flow onto and are raked down the sloped table; the water falls through the openings. One of the trap doors to control the rate of flow is located at the end of the chute (right center).

1/ Complete details on this construction work may be obtained by writing to the Ketchikan (Alaska) or Seattle (Washington) Technological Laboratories.

sacks, that is, placed the polyethylene bag inside the burlap bag (figure 7).

Figure V-4. Another view of the draining table shows the viscera flowing down the chute, through the trap door, and onto the draining table.

At approximately 3:15 p.m. each day, a dump truck transported the day's output to the cold-storage plant. Two trips were usually necessary. The collection crew of four men loaded the truck, and two of the men (cold-storage workers) accompanied the truck to the cold-storage plant where the sacks were dumped near the freezer door. These men then hand-trucked the sacks into the freezer (average temperature of -18° F.) and placed them on the freezer plates (figure 8). This operation usually took two men approximately one hour per 100 sacks. Each day two hand-truck loads of sacks (10 sacks per truck) were weighed. The average weight was approximately 65 pounds per sack.

Normally the sacks of viscera were solidly frozen in 24 hours. After 300 to 400 sacks accumulated in the freezers, they were moved to the storage room by the regular cold-storage plant crew (figure 9).

Problems Encountered

Figure V-5. The drained viscera are sacked (right) and the burlap bag is wire-tied (center).

Following are the two main problems encountered during the collection: (1) Fish missed by the iron chink (that is, the fish fed into the iron chink that were not carried through but dropped) would fall onto and clog the fin grate (figure 2). The fins would then rapidly pile up on the floor. When this build-up of material became too high the fins would wash underneath the chink, down through the rear grate (figure 1) into the viscera chute, and then onto

Figure V-6. The sacks of viscera are loaded onto the elevator and are hand-winched from the platform up to the dock level.

the draining table where they had to be picked out from the visceral portion. The only remedy for the above problem, without interfering with the cannery operation, was to periodically clean off the fin grate. This solution was not ideal. (2) Separation of the soft visceral portions made disposal of the remainder of the trimmings more difficult. Ordinarly, the whole waste flowed easily from the gurry bin into the scow. Since approximately 85 percent[2/] of the viscera, or soft portions, were diverted for the collection operation, very little of this material entered the cannery's gurry bin. The mass of heads, tails, and fins were difficult to remove from the bin. This difficulty required the use of additional personnel to empty the bin and then to dump the scow; normally, one man carried out the entire operation. This problem could possibly be solved by building more slope into both bin and gurry scow.

Under optimum conditions (when this particular cannery was running all three iron chinks steadily), a maximum of thirty-five 65-pound sacks of viscera were collected in an hour. These conditions were seldom attained because most of the collection was made during the first half of the season at a time when the cannery was not operating at full capacity. An average of 120 sacks per day (range of 90 to 150) was collected with the facilities used.

During an eight-hour shift, only one-half to three-fourths of the time of the workers was spent in actual collection of the material. The remainder of the time was spent in taking the material to the cold-storage plant, emptying the gurry bin and dumping the gurry scow, and making minor adjustments to and cleaning the equipment. Also, the collection was carried out over only a portion of the season, and only until the desired quota of 100,000 pounds was reached. Had operations continued for the final ten days of the season, the prorating of certain fixed costs and capital investments for a larger production would have resulted in a smaller

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2/ It is estimated that 60 to 70 percent of the theoretical yield of viscera was collected. This value was based on the estimate of 25 pounds of whole waste per case of salmon. The viscera represent 29 percent of the whole waste or 7.3 pounds of viscera per case of salmon. Some of the loss of viscera, probably up to 15 percent of the total amount, occurred at the draining table where the small portions fell through the slots.

unit cost per pound of the viscera and eggs.

Costs of Collection of Waste

Table 1 lists the costs of collecting the salmon viscera. Only the costs of the actual materials and services necessary for the viscera collection are given.

Cost of all man hours involved in the actual collection are figured at the rate of $2.00 per man hour straight time and $3.00 per man hour overtime.

Figure V-7. The men are pulling the polyethylene bag over the sack stand; a burlap bag (upper center) is then pulled over on the outside of the polyethylene bag. The completed containers are piled on the stand behind the man on the left.

Table 2 gives information on the cost breakdown for the collection of frozen salmon eggs; table 3, information on shipping costs from Petersburg, Alaska, to Seattle; and table 4, costs in cents per pound for collection of salmon viscera and eggs, calculated f.o.b. Petersburg and f.o.b. Seattle. The cost f.o.b. Seattle of the viscera is 5.21 cents, and of the eggs is 7.75 cents per pound (not including capital investments or depreciation). In comparison, the Fish and Wildlife Service hatcheries in 1951 paid 9 cents per pound for eggs obtained in the Pacific Northwest. The price paid for salmon waste has varied with the degree of separation of the heads, tails, and fins from the soft visceral parts. The amount paid for the viscera, equal in quality to that obtained in this collection, has been greater than 5 cents per pound.

Observations on the adequacy of packaging, using the polyethylene bags within burlap, were made by Service personnel during handling at Petersburg and on arrival at destination. Examination by representatives of a commercial steamship company was made at destination.

The container employed for this purpose was a 0.002-inch thick polyethylene transparent bag, (19 inches wide and 42 inches long) placed inside a burlap bag (18 inches wide by 36 inches long). The burlap bag, being smaller than the plastic liner, takes up most of the strain during packing, freezing, and handling operations. This size of bag would hold, if filled completely, about 100 pounds of material. However, by placing only 65

Table V-1. Cost of Collection of 100,750 Pounds of Salmon Viscera F.O.B. Steamship Dock, Petersburg, Alaska

Item	Cost
Material: 1,600 burlap bags	$ 479.00
1,600 polyethylene liners	258.00
2,000 wire ties	5.00
1 wire-tying tool	2.00
Shipping Seattle to Petersburg	18.00
Viscera (100,750 lbs. at $0.005 per lb.)	503.75
Freezing and Storage ($7.00 per 1,000 lbs.)	705.25
Hauling by Transfer Co. ($6.00 per hour)	50.00
Labor for the Collection (396.5 hrs. at $2.00 per hr.) 35 hrs. at $3.00 per hr.)	898.00
Cold-Storage Handling Charges	87.00
Longshoring	78.00
	$3,084.00

Table V-2. Cost of Collection of 3,000 Pounds of Frozen Eggs F.O.B. Steamship Dock, Petersburg, Alaska

Item	Cost
Material: 30-lb. Berry Tins and Lids	$ 38.00
Shipping Cost Seattle to Petersburg	35.00
Eggs ($0.005 per pound)	15.00
Labor for Collection	56.00
Freezing and Storage	21.00
Cold-Storage Handling Charge	2.50
Longshoring	6.50
Hauling by Transfer Co.	3.00
	$ 177.00

Table V-3. Shipping Cost of Salmon Viscera and Eggs from Petersburg, Alaska to Seattle, Washington

Item	Cost
Transportation of 1,550 sacks of Viscera (2,722 cu. ft. at $0.675 per cu. ft.)	$1,837.35
Wharfage and Handling (Petersburg and Seattle) (2,722 cu. ft. at $0.12125 per cu. ft.)	330.04
Total	$2,167.39
Transportation of 100 Cans of frozen eggs (66.8 cu. ft. at $0.7125 per cu. ft.)	$ 47.60
Wharfage and Handling (Petersburg and Seattle) (66.8 cu. ft. at $0.12125 per cu. ft.)	8.10
Total	$ 55.70

pounds of material in the bags, handling was greatly facilitated. Greater ease in closing the polyethylene bag resulted inasmuch as it was possible to tie a knot in the polyethylene bag for a rapid, secure closure. It seems that 65 pounds is the best weight for ease of handling; also, this size package fits between freezer plates more readily than a 100-pound size.

Table V-4. Summary of Costs for Salmon Viscera and Eggs

	Price Per Pound F.O.B. Steamship Dock, Petersburg, Alaska	Shipping Cost, Per Pound, From Petersburg, Alaska, to Seattle, Wash.	Price Per Pound F.O.B. Steamship Dock, Seattle, Wash. 1/
	Cents	Cents	Cents
Viscera (in bags)	3.06	2.15	5.21
Eggs (in 30-lb. berry tins)	5.90	1.85	7.75

1/ Capital investments and depreciation costs not included, since they would ordinarily be pro-rated for the entire season over a period of years. Also, the costs will vary with the location of the cannery, rates for labor, type of construction, and environmental conditions. For this particular operation the cost of miscellaneous supplies and construction required for the entire collection amounted to $413.19. This amount, undoubtedly, will represent an average investment that might be expected for a three-line salmon-cannery operation.

The 65-pound bags of unfrozen salmon viscera were subjected to extremely rough handling without rupturing the polyethylene liners or otherwise damaging the bags. Unfrozen bags of viscera were loaded into a dump truck for transportation from the cannery to the freezer. Upon arrival at the freezer, they were dumped onto the floor, during which process some bags fell 6 feet or more onto the concrete floor or onto other bags. This rough treatment did not necessitate the rebagging of a single container.

The bags were still in excellent condition after they were handled in the usual manner, at the cold-storage plant and after they were unloaded at Bellingham or Seattle, Washington. No difficulty was experienced in bags sticking to freezing plates or to each other.

Figure V-8. The sacks of viscera are lying on the freezer plates (left) where they are normally frozen solid in 24 hours; the cans containing the eggs were frozen while stacked on the floor.

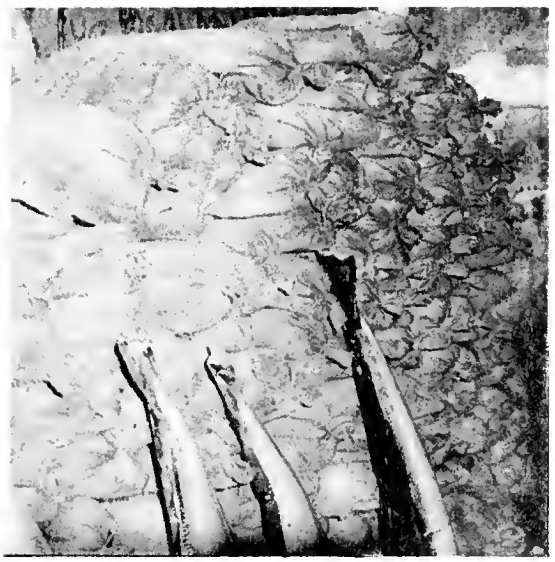

Figure V-9. The frozen sacks of viscera are stored in regular cold-storage room awaiting shipment to Seattle; the fish (bottom center) are frozen halibut.

The containers were clean with no fish material adhering to them. Inspection of the shipment at different points en route to the hatchery and after arrival at the hatchery failed to show a single bag which had lost any of its contents or which needed rebagging for any reason whatever.

The shipments from Alaska to Washington were made in two lots. The first shipment of about 60,000 pounds would not be accepted by any commercial steamship company because, contrary to regulations, the viscera were packed in bags rather than metal containers. The first shipment was made aboard a refrigerated vessel belonging to one of the salmon canneries, and delivery was made at Bellingham, Washington. Inspection of this shipment by representatives of a regular commercial steamship company convinced them that such a method of packaging would probably be satisfactory. Accordingly, they agreed to ship the second lot of about 40,000 pounds. This shipment was in excellent condition when it arrived in Seattle. The steamship company officials indicated, therefore, that future lots of salmon viscera bagged and frozen as indicated herein would be accepted for shipment from Alaska to Seattle on their regular commercial refrigerated vessels.

Acknowledgment

Acknowledgment is made to: Pacific American Fisheries, Inc., for the use of their facilities, and in particular to Mr. Ivan Finsberg, superintendent; Mr. Ralph Erickson, foreman; and other personnel at the company's cannery at Petersburg, Alaska, whose cooperation and assistance made this salmon waste collection possible; the Alaska Fisheries Experimental Commission for the use of their facilities and personnel; Mr. William A. Hagevig, Laboratory Assistant for the Alaska Fisheries Experimental Commission, for assistance in the planning and engineering the installations made at the cannery and for assisting in the collection of the viscera.

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